Pipe Outlet Protection

Definition: Structurally lined aprons or other acceptable energy dissipating devices placed at the outlets of pipes.

Purpose: To prevent scour at storm water outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated storm water flows.

Conditions Where Practice Applies: Applicable to the outlets of all pipes where the velocity of flow at design capacity of the outlet will exceed the permissible velocity of the receiving channel or area. Table 4, of the grassed waterway standard may be used to determine permissible velocity.

Planning Considerations

The outlets of pipes are points of critical erosion potential. Storm water which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at storm water outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

The most commonly used device for outlet protection is a structurally lined apron. These aprons are generally lined with riprap, grouted riprap or concrete. They are constructed at a zero grade for a distance which is related to the outlet flow rate and the tailwater level. Criteria for designing such an apron are contained in this practice.

Where flow is excessive for the economical use of an apron, excavated stilling basins may be used. Acceptable designs for stilling basins may be found in Design Note 6 of the Soil Conservation Service.

The standard for lined waterways may be used to design outlet protection when water is discharged into road ditches or similar outlets.

Design Criteria

Structurally lined aprons at the outlets of pipes shall be designed according to the following criteria:

1. **Tailwater depth:** The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth. If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a **Minimum Tailwater Condition**. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a **Maximum Tailwater Condition**. Pipes which outlet onto flat areas with no defined channel may be assumed to have a **Minimum Tailwater Condition**.

2. **Apron length:** The apron length shall be determined from the attached curves according to the tailwater condition:

3. **Apron width:** If the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an

elevation one foot above the maximum tailwater depth or to the top of the bank (whichever is less).

If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

a. The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.

b. For a **Minimum Tailwater Condition**, the downstream end of the apron shall have a width equal to the pipe diameter plus the length of the apron.

c. For a **Maximum Tailwater Condition**, the downstream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron.

4. **Bottom grade:** The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

5. **Side slopes:** If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (Horizontal: Vertical).

6. **Alignment:** The apron shall be located so that there are no bends in the horizontal alignment.

7. **Materials:** The apron may be lined with riprap, grouted riprap, or concrete. The median sized stone for riprap shall be determined from the attached curves according to the tailwater condition. Riprap shall conform to the following requirements:

a. The riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50% of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size.

b. The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter but not less than 6 inches.

c. Stone for riprap shall consist of field stone or durable quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all other respects for the purpose intended.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot.

d. A filter composed of graded aggregate or filter cloth may be required beneath the riprap.

Sample Problems Outlet Protection Design

Example 1

Given: An 18-inch pipe discharges 24 $ft.^3$/sec. at design capacity onto a grassy slope (no defined channel).

Find: The required length, width and median stone size (d_{50}) for a riprap-lined apron.

Solution:

1. Since the pipe discharges onto a grassy slope with no defined channel, a Minimum Tailwater Condition may be assumed. (Figure 26)

2. From the attached curves an apron length (La) of 20 feet and a median stone size (d_{50}) of 0.8 ft. are determined.

3. The upstream apron width equals three times the pipe diameter; 3 x 1.5 ft. = 4.5 ft.

4. The downstream apron width equals the apron length plus the pipe diameter; 20 ft. + 1.5 ft. = 21.5 ft.

Example 2

Given: The pipe in example No. 1 discharges into a channel with a triangular cross-section, 2 feet deep and 2:1 side slopes. The channel has a 2% slope and an "n" factor of .045.

Find: The required length, width and the median stone size (d_{50}) for a riprap lining.

Solution:

1. Determine the tailwater depth using Manning's Equation.

$$Q = \frac{1.49 \quad R^{2/3} \quad S^{1/2} \quad A}{n}$$

$$24 = \frac{1.49}{.045} \left[\frac{2d}{2\,(2^2 + 1)^{1/2}} \right]^{2/3} (.02)^{1/2}\,(2d^2)$$

where,
d = depth of tailwater
d = 1.74 ft.*

*Since d is greater than half the pipe diameter, a Maximum Tailwater Condition exists. (Figure 27)

2. From the attached curves, a median stone size (d_{50}) of 0.5 ft. and an apron length (La) of 41 ft. is determined.

3. The entire channel cross-section should be lined, since the maximum tailwater depth is within one foot of the top of the channel.

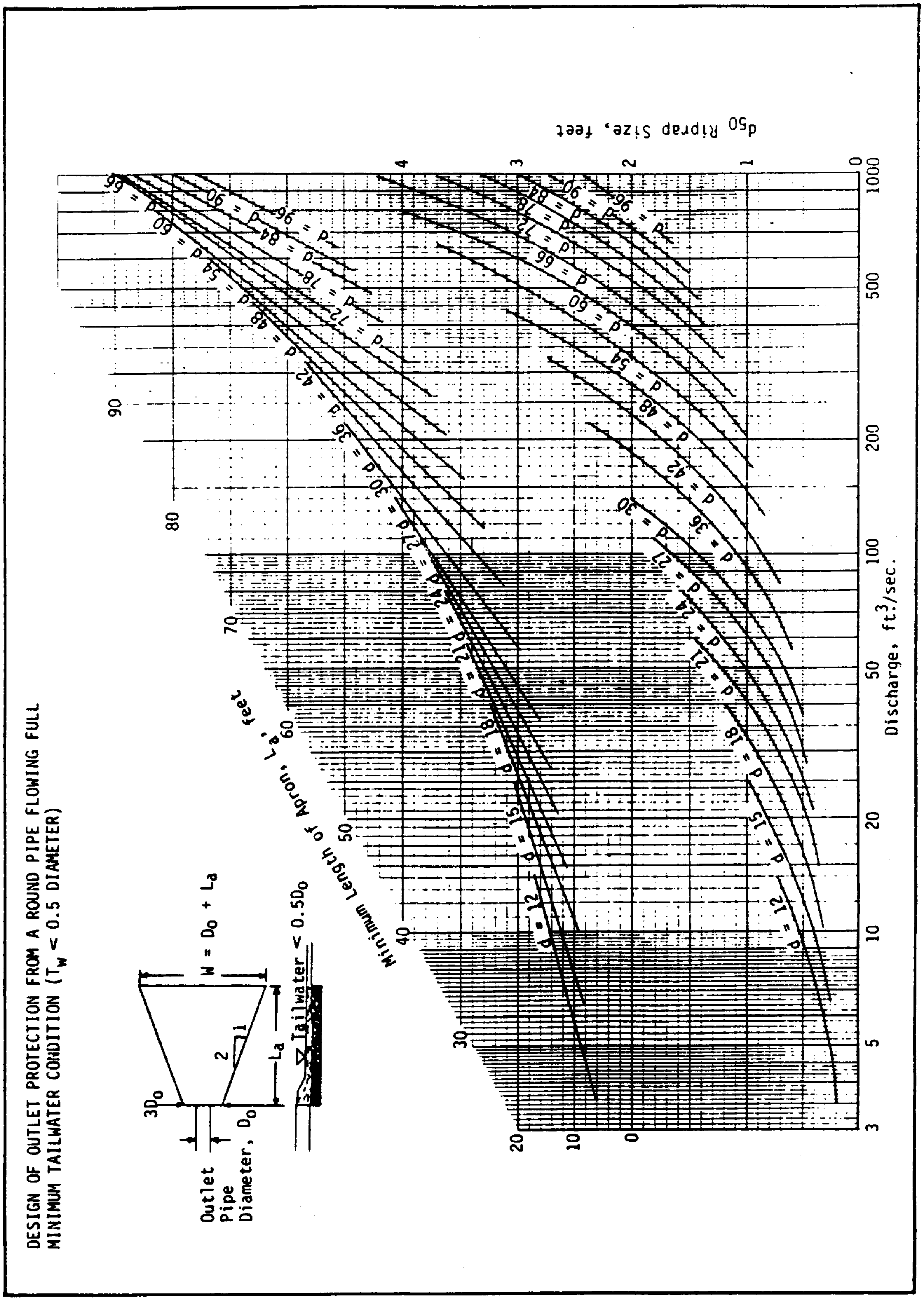

Figure 26 — Minimum Tailwater Condition

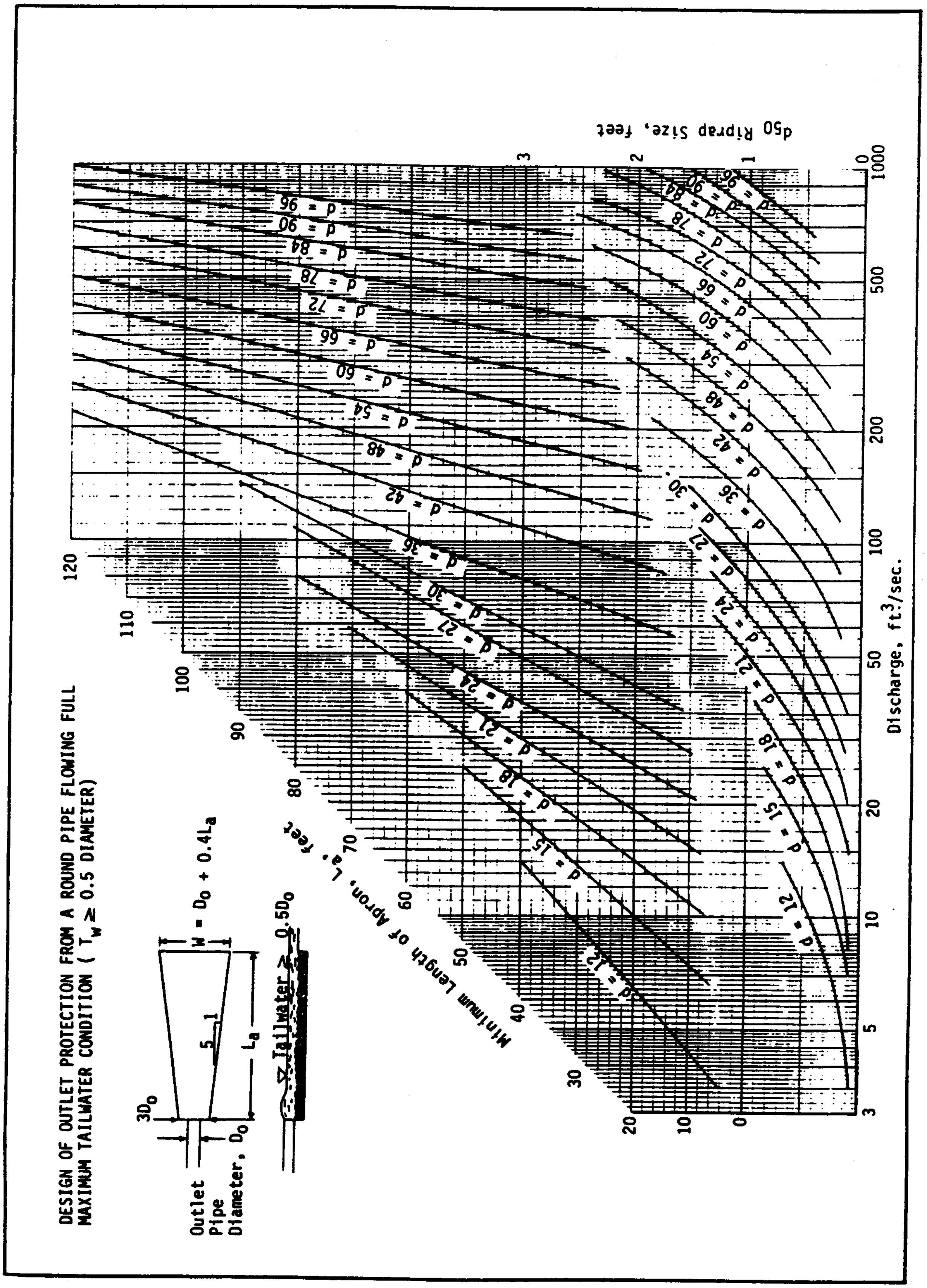

Figure 27 — Maximum Tailwater Condition